Comprehensive Assessment of Performance and Emission Characteristics of Pumpkin Seed Oil with $(C_2H_5)_2O$ and Jojoba Seed Oil with $C_5H_{12}O$ in C.I Engine

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Abstract

Bio-Diesel is an inexhaustible asset and a good alternative to conventional diesel fuel. The supply and demand holds to develop alternative fuels, which was stimulated by the depletion of the fossil fuel due to the limited resources. The main aim of the current study is to evaluate the performance and emission characteristics of a dual fuel was formulated using diesel with pumpkin seed oil as pilot fuel blended with diethyl ether as additive and jojoba seed oil as primary fuel blended with 1-pentanol as additive in a dual fuel engine. The performance parameters like brake specific fuel consumption, brake thermal efficiency and exhaust emissions of CO, CO_2, HC and NOx were determined. The testing can be done at constant speed at 1500 rpm. The comparative statement from this experiment of bio oils reveals that a significance improvement in the results of engine performance and emission characteristics of C.I engine.

Keywords: *Pumpkin Seed oil, Jojoba seed oil, Diethyl ether, 1- pentanol*

1. Introduction

Vegetable oil can be used as an alternative fuel in diesel engines due to the foreseen scarcity of non-renewable energy, the study of the future fuel is an unavoidable target. A research reported that the cotton seed methyl ester was used as an alternative fuel which yields, the engine torque and power was lower than that of diesel fuel varies in the range of 3-9%, SFC consumption was higher than the diesel in the percentile of 8-10% and the carbon-dioxide, carbon-monoxide and NOx emission is found to be lower than diesel fuel [1]. Pumpkin seed has considerable oil content by nature, the oil from the seed can be converted into methyl ester and various blend ratios were examined and compared with diesel fuel. Tests were performed at different loads condition in a single cylinder, four stroke and air cooled direct injection diesel engine developing power of 4.4 kW at rated speed of 1500 rpm. The result reveals that the combustion analysis, it is found that 40% volume basis considered as an optimum blend. The maximum heat release rate occurs for diesel fuel and followed by pumpkin oil methyl ester diesel blends [2]. Jatropha methyl ester is used as a bio-oil and blends with diesel and butanol through transesterification process with a catalyst sodium meth-oxide. The results of the comparative statements reports using methanol and ethanol, further the reaction rates and impacts were discussed. The performance measures were evaluated such as BSEC and brake thermal efficiency along with emissions of hydro-carbon, carbon-monoxide, NOx for the test fuels. The performance parameters are evaluated and found to be lower for all the blends in case of

BSFC, the CO emission were found to be lower than neat diesel fuel, a gradual increase in the percentage of Carbon dioxide emission with the increase in butanol mixture in the blended fuels running at different loads [3]. An unmodified diesel engine was used for the experimental work, the effect of palm oil methyl ester as an alternative fuel. The condition of the engine set to be a constant 2500 rpm maintained throughout the lubrication period. To enquiry the effects of ordinary diesel fuel with palm oil bio-diesel and their emulsion of the engine components [4]. The emission characteristics of five different fuels were investigated with the base diesel fuel under full load condition. The engine performance parameters likely to be engine power, torque, BSFC, thermal efficiency and emissions were measured. Jojoba ethyl ester and its blends with ethanol as good biodiesel [5]. The pongamia oil was mixed with the conventional lubricant in the ratios 15, 30 and 50% by volume. The investigation of the friction and wear behavior of pongamia oil blends was carried out using a pin-on-disc tribometer found that the lubrication regime that occurred during the test was boundary lubrication and the wear obtained was abrasive and adhesive in nature [6]. An experiment was conducted on papaya methyl ester to study the performance and emission characteristics of n-butanol The BTE was found to increase with the blends, the effects of n-butanol addition could be clearly detected at medium load for HC and CO emissions. NOx emissions deviated at higher loads [7]. The ethanol bio-diesel blends used for engine performance, emission and combustion using bio-diesel produced from waste cooking oil compared to neat biodiesel. The ethanol blended biodiesel produces lower Brake specific CO, BSHC and BSPM emissions, while higher BSNOx and $BSNO_2$ emissions [8,9]. Energy from used non-edible Jatropha oil is recovered and utilized in the diesel engine. The effect of jatropha oil biodiesel used in CI engine. The works discuss the effect of decanol with neat Jatropha oil biodiesel. The result reveals that NOx of Jatropha bio-diesel (pure) is 10.65% higher than diesel (pure). The inclusion of 10% decanol in pure jatropha bio-diesel reduces NOx emission by 5% and 6% compared jatropha bio-oil and pure diesel [10, 11, 12]. The pumpkin seed oil and juliflora seed oil are converted to fatty acid, by adding 15 grams potassium hydroxide (KOH) as catalyst for transesterification. Diethyl ether as the additive was added to the above blend and the engine was operated with no load to full load and in over load condition was favour a possible outcomes from the study [13]. Elaeocarpus Ganitrus (EG) seed oil was used for the synthesis of biodiesel. Performance tests were carried out using biodiesel blends in single cylinder diesel engine and exhaust emissions were recorded using a five-gas analyser [14]. The biodiesel obtained from transesterification process of Pumpkin and Maize is used as an alternative fuel to diesel. The performance, combustion and emission test using Pumpkin-Maize (PM) biodiesel and their blends (10%, 20%, 30%, 40% and 50%) with diesel were carried out at variable loads conditions [15]. Two biodiesels in equal weight ratio namely Cucurbita pepo.L (pumpkin) and Tectona grandis (teak) seed oil was used for the synthesis of biodiesel with 5-ml Diethyl ether as additive to investigate the performance and emission test [16]. The study of review on alternative fuel characteristics, alongside their utilisation and production opportunities was examined. To come up with the optimal solutions, the authors compared various proposed alternative fuels [17]. The performance and emissions at different engine's loads have been studied through fuel blends tests on CI Engine and to analyse the consequence of papaya seed oil biodiesel with presence of ignition promoter in coated and uncoated engine characteristics [18, 19, 20]. The current study discusses about the performance, emission characteristics of pumpkin seed oil and Jojoba seed oil through a comparative study.

2. Experimental Setup

The study of engine performance has been an important process since the evolution of the engines. In the very early stages, only the external performance was studied with help of loading with a dynamometer and measuring the parameters like torque, output power, specific fuel consumption (SFC) etc., as the world progressed further, the necessity of refinement of engine design was considered to be an inevitable process in the role of performance. Test engine used in the experiment is a single cylinder direct injection Kirloskar diesel engine. It is naturally aspirated water – cooled four stroke diesel engine. The Kirloskar engine is one of the widely used engines in agricultural, pump sets, farm machinery and medium scale commercial purposes. The schematic representation of engine setup was shown in Figure 1.

Figure 1. Engine setup

2.1 Preparation of Pumpkin seed Bio-oil and blend ratios

Pumpkins have been cultivated for various reasons ranging from nutritional to medicinal purposes. Pumpkin seed oil has been extracted from different tropic regions with variations in the range of the oil content. For example, oil content ranging from 34.5 to 43.6% was reported in eight lines of cucurbita pepo, 10.9 to 30.9 for cucurbita maxima, 27.83% for cucurbitaceae maxima, 50% for gourds and 44 – 54% for cucurbitaceae cultivated in Cameroun. Dimethyl ether is the simplest ether with a chemical formula of $(C_2H_5)_2O$ .The physical properties of dimethyl ether are similar to those of liquefied petroleum gases (i.e., propane and butane). Dimethyl ether burns with a visible blue flame and is non-peroxide forming in the pure state or in aerosol formulations.

Pumpkin seed bio-oil blend ratios

- B100 (100% pure biodiesel)
- B80 (80% pumpkin oil, 20% diesel)
- B60 (60% pumpkin oil, 40% diesel)
- B40 (40% pumpkin oil, 60% diesel)
- B20 (20% pumpkin oil, 80% diesel)

2.2 Brake Specific fuel consumption

The variation of Specific fuel consumption for various blends of pumpkins seeds bio-oil. It shows a gradual decrease in specific fuel consumption on increasing loads and by reduction in heat loss and better combustion at higher loads. Under full load conditions exhibited more specific fuel consumption than neat diesel. This increase in specific fuel consumption with addition of pumpkins seed oil is due to the lower heating value of pumpkin seed oil biodiesel blends. It is evident from Figure.2 that the relation between brake specific fuel consumption (BSFC) and load was graphed for pumpkin seed.

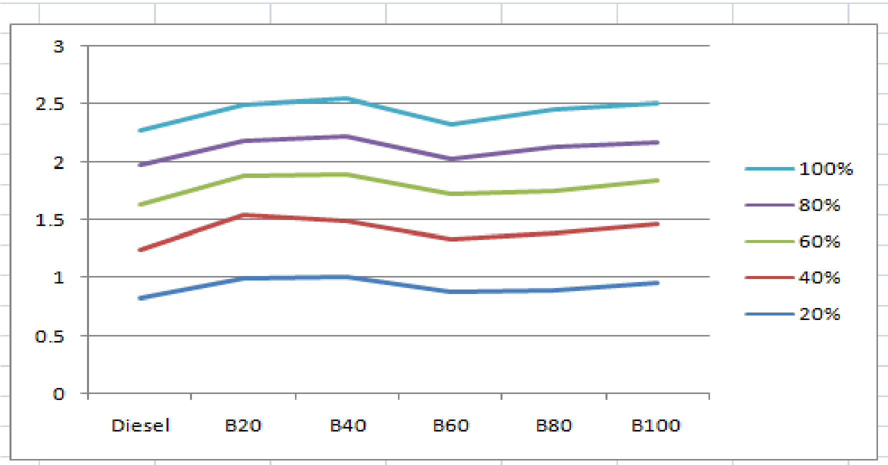


Figure 2. Load vs BSFC of Pumpkin seed

2.3 Brake thermal efficiency

The variations of brake thermal efficiency for different blends of fuel at varying load were illustrated. Brake thermal efficiency steadily increased with increase of loads higher power is developed due to the better mixing of fuel and air at higher loads, compression ratios. Hence, the Brake thermal efficiency increases. Neat diesel showed lower brake thermal efficiency than blends of pumpkin seed oil at lower load at higher load neat diesel shows higher BTE then bio-oil blends. Figure.3 represents the relation between brake thermal efficiency (BTE) and load for pumpkin seed oil.

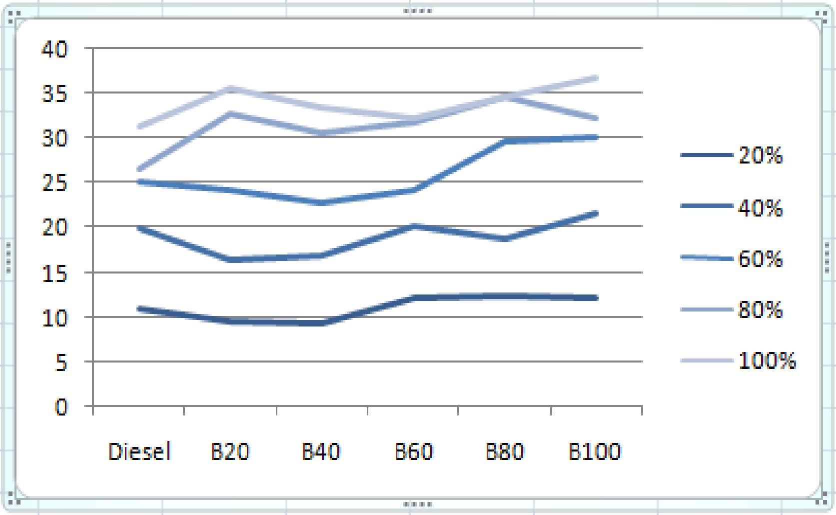


Figure 3. Load vs BTE for pumpkin seed

3. Emission Characteristics

Emission characteristics help in determining the amount of detrimental gases released and the possible challenges associated with a fuel are stated below

3.1 Emission of Hydrocarbon (HC)

The exhaust of unburnt carbons results in emission of hydrocarbons. In partial loading, the emission of hydrocarbon and its various blends were found to be lower, also increase in lower and higher engine load. This is due to less oxygen for the reaction, when more fuel is injected into the engine cylinder at higher engine load. Figure 4 represents the emission of HC of pumpkin seed for varying load ratios.

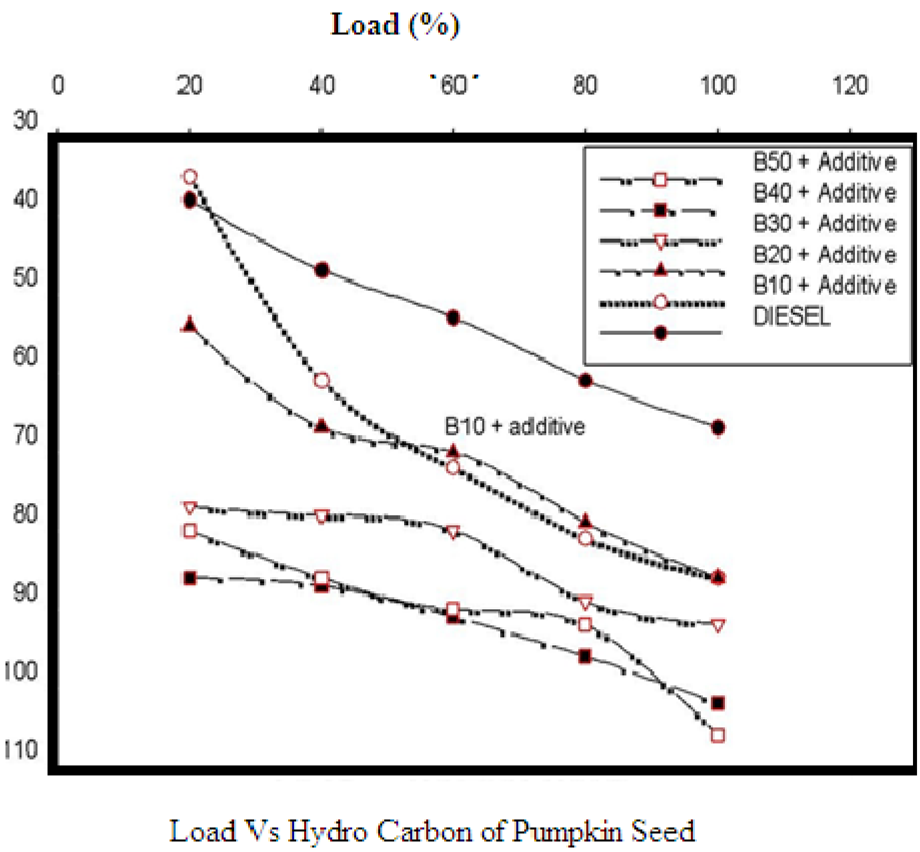


Figure 4 Load vs Hydro carbon of Pumpkin seed

3.2 Emission of Carbon Monoxide (CO)

Varying loads determines the variation in carbon monoxide, due to the heterogeneity of the cylinder and semi oxidation of hydrocarbon in the exhaust section. The load increases results in CO emission decreases, more are less very similar variation in pumpkin seed bio-oil compared to diesel fuel. Figure 5 represents the emission of CO for varying load ratios.

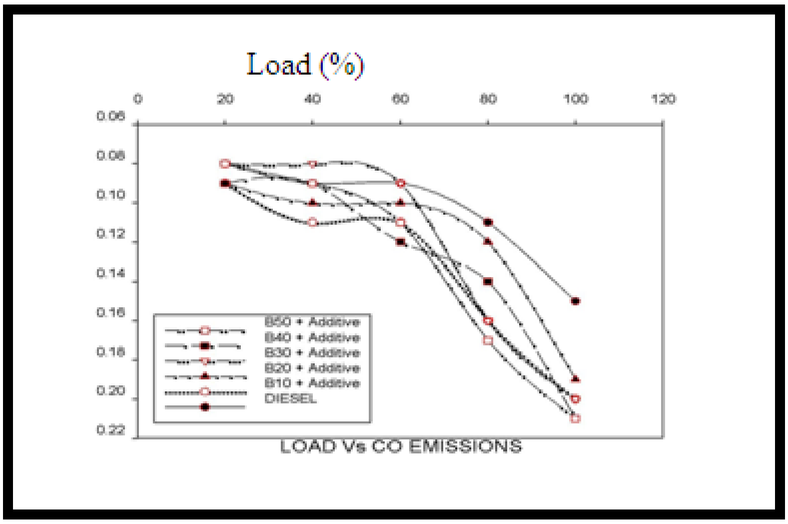
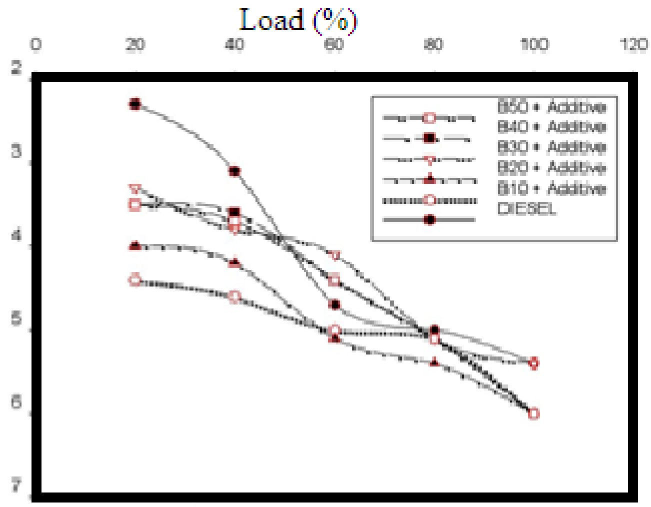


Figure 5 Load vs Carbon monoxide Emissions of pumpkin seed

3.3 Emission of Carbon dioxide (CO_2)

Complete combustion of the fuel in oxygen forms carbon dioxide, the calorific value of the fuel is low, and more fuel needs to be burnt to get equivalent power output. So combustion of more carbon compounds leads to higher carbon dioxide emission. Figure 6 represents the emission of CO_2 for varying load capacity.



Load Vs Carbon Dioxide Emission

Figure 6 Load vs Carbon dioxide (CO_2) Emissions of pumpkin seed

3.4 Emission of Nitrogen oxide (NOx)

The oxygen and heat generation (temperature) are the two important factors, leads to the formation of nitric acid. By increasing load from 0 to 100%, nitric oxide emission is increasing; this is due to that most vegetable oils contain small quantities of nitrogen containing proteins. The small amount of nitrogen in addition to atmospheric nitrogen releases extra NO emissions through combustion. Figure 7 represents the emission of NOx for varying load ratios.

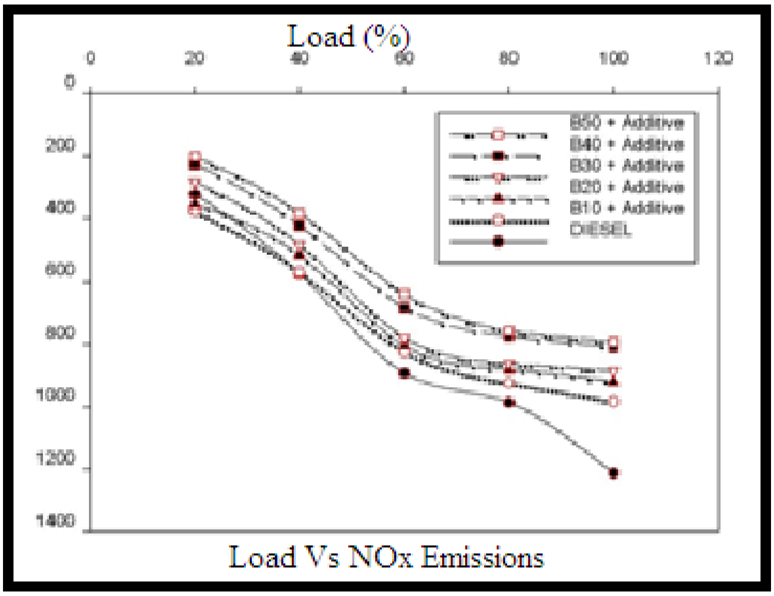


Figure 7 Load vs Nitrogen Oxide Emissions of pumpkin seed

4. Preparation of Jojoba Bio-oil and blend ratios

Jojoba oil is the liquid produced in the seed of the Simmondsia chinensis (Jojoba) plant, a shrub, which is native to southern Arizona, southern California, and northwestern Mexico. The oil makes up approximately 50% of the jojoba seed by weight. The terms "jojoba oil" and "jojoba wax" are often used interchangeably because the wax visually appears to be a mobile oil, but as a wax it is composed almost entirely (~97%) of mono-esters of long-chain fatty acids and alcohols, accompanied by only a tiny fraction of triglyceride esters. This composition accounts for its extreme shelf-life stability and extraordinary resistance to high temperatures, compared with true vegetable oils. Figure 8 represents the jojoba seed.

Figure 8 Jojoba seed

1-Pentanol, (or n-pentanol), is an alcohol with five carbon atoms and the molecular formula $C_5H_{11}OH$. 1-Pentanol is a colorless liquid with an unpleasant aroma. It is the straight-chain form of amyl alcohol, one of 8 isomers with that formula. The hydroxyl group (OH) is the active site of many reactions. The ester formed from 1-pentanol and butyric acid is pentyl butyrate, which smells like apricot. The ester formed from 1-pentanol and acetic acid is amyl acetate (also called pentyl acetate), which smells like banana.

Jojoba seed bio-oil blend ratios

- B100 (100% pure biodiesel)
- B80 (80% jojoba oil, 20% diesel)
- B60 (60% jojoba oil, 40% diesel)
- B40 (40% jojoba oil, 60% diesel)
- B20 (20% jojoba oil, 80% diesel)

The detailed load calculation based on BTE and BSFC of the C.I Engine for Jojoba seed biodiesel are given in Table 1 and 2 respectively.

Table 1. Calculation of Load Vs Brake Thermal Efficiency

	Brake Thermal Efficiency (BTE)				
	Load 20%	Load 40%	Load 60%	Load 80%	Load 100%
Diesel	11.93	23.04	23.94	25.35	29.07
B20	9.77	17.59	24.87	31.55	33.99
B40	9.33	17.98	23.93	28.62	31.57
B60	12.15	22.16	26.51	32.51	34.20
B80	12.26	19.96	27.66	32.00	33.69
B100	11.54	20.64	28.08	30.60	34.85

* Speed Constant 1500 rpm

Table 2. Calculation of Load Vs Brake Specific Fuel Consumption (BSFC)

	Brake Specific Fuel Consumption (BSFC)				
	Load 20%	Load 40%	Load 60%	Load 80%	Load 100%
Diesel	0.716	0.371	0.357	0.338	0.29
B20	0.905	0.502	0.355	0.280	0.260
B40	0.977	0.507	0.382	0.319	0.289
B60	0.775	0.425	0.355	0.289	0.276
B80	0.794	0.488	0.352	0.304	0.305
B100	0.872	0.488	0.359	0.329	0.289

From the figure 9, it was noted that the BTE was getting increased with the increase in load for all fuel samples. The increase in BTE with the increase in load was due to low heat losses at higher loads.

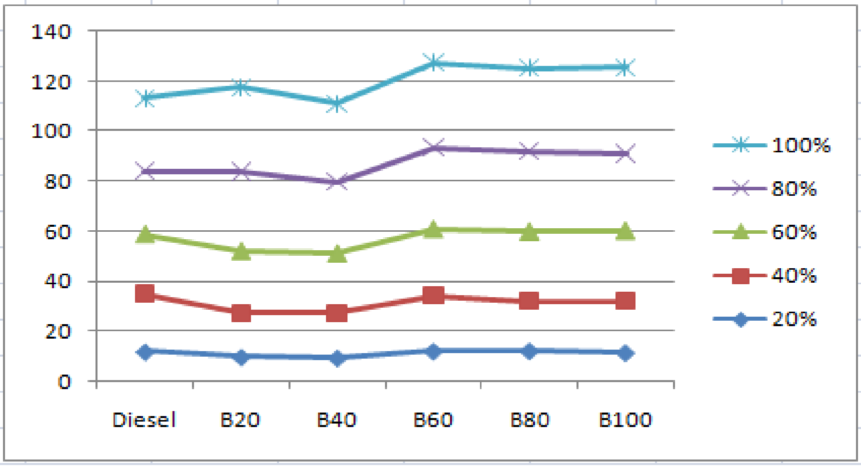


Figure 9 Load vs BTE

From the figure 10, it was noted that for all fuels, the BSFC was getting decreased with the increase in load. Moreover, the percentage increase in biodiesel increased the BSFC.

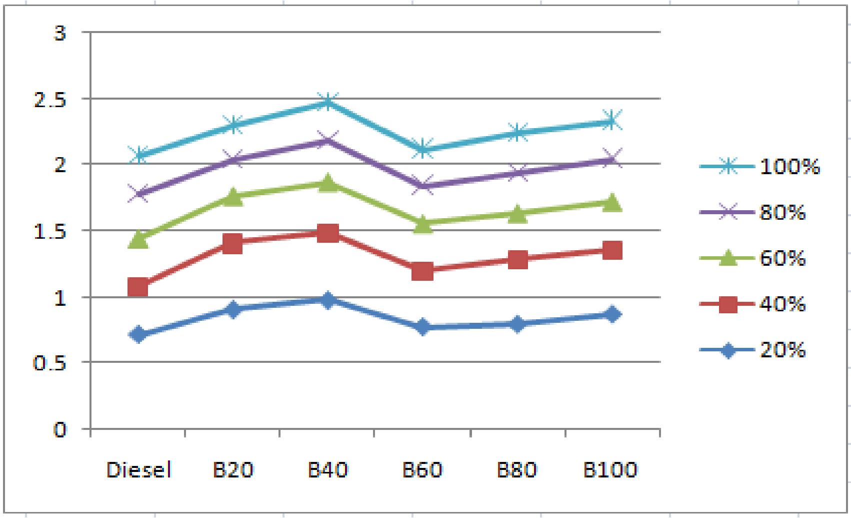


Figure 10 Load vs BSFC

The figure. 11 shows the amount of NOx present in the engine exhaust with respect to load. The formation of NOx highly dependent on the in-cylinder temperature, oxygen concentration and residence time for the reaction to take place. Here it was observed that the NOx emission was increased with the increase in load for all fuels.

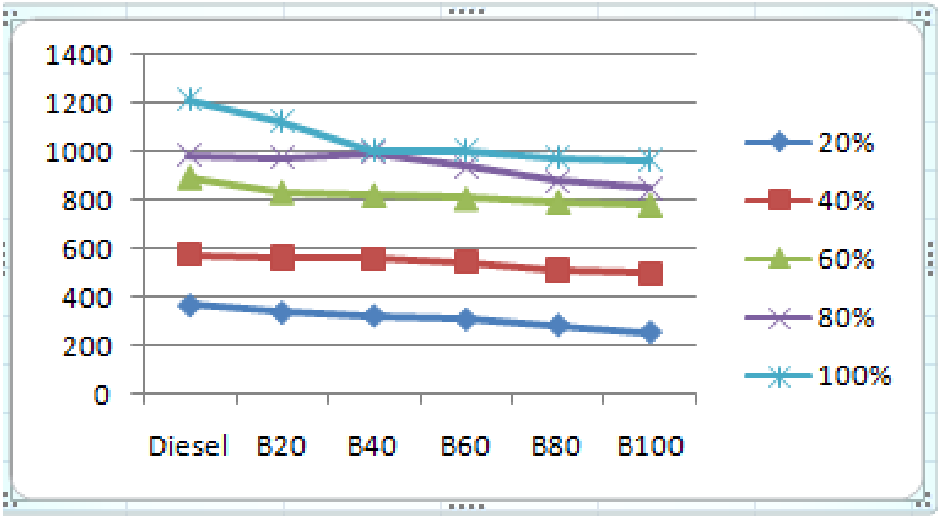


Figure 11 Load vs NOx Emission

Figure. 12 represents the relation between CO emission and load. Here, it was noted that the CO emission was decreased gradually based on load acting on the engine for all fuels, then the CO emission was gradually increased up to 60% load, and after that it was increased rapidly up to full load. The sharp increase in CO emission at full load was because, when at high load the mixture supplied to the engine was rich

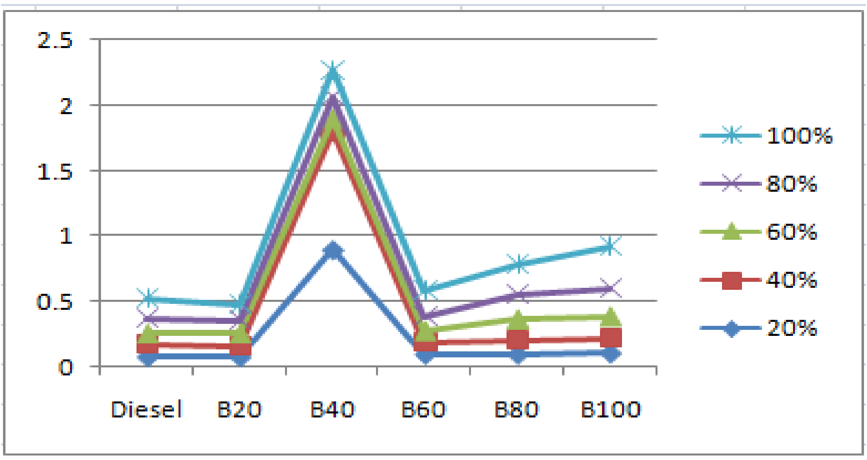


Figure 12 Load vs CO Emission

The variation in CO_2 emissions is shown in the Figure. 13. In the range of whole engine load, the CO_2 emissions of diesel fuel are lower than that of Maize biodiesel and its blended fuels. This is because biodiesel contains oxygen element, the carbon content is relatively lower in the same volume of fuel consumed at the same engine load and consequently the CO_2 emissions from the vegetable oil and its blends are lower.

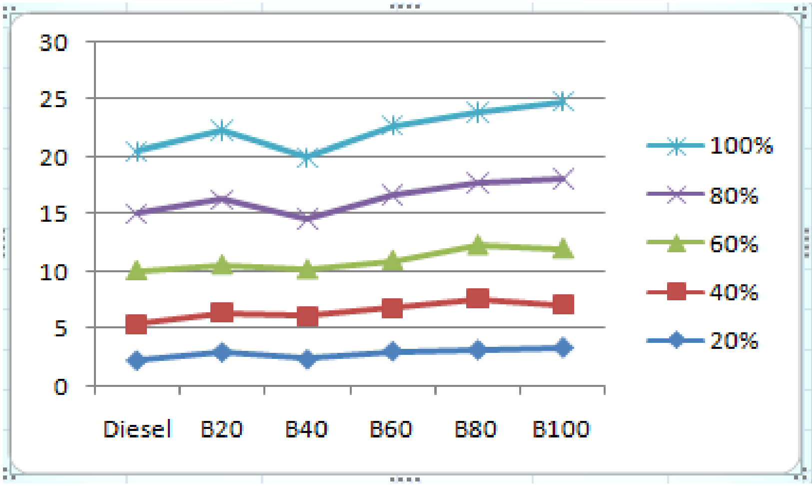


Figure 13 Load vs CO_2 Emission

The effect of load on un- burned hydro-carbon (HC) emissions for diesel, neat Maize biodiesel and their blends is shown in Figure 14. It can be seen from the figure that the lower HC emissions were obtained with blends of Maize biodiesel-diesel and neat Maize biodiesel mode of operation for loads above 60%. Lower HC emissions in the exhaust gas of the engine may be attributed to the efficient combustion of Maize biodiesel and blends due to the presence of fuel bound oxygen and warmed-up conditions at higher loads.

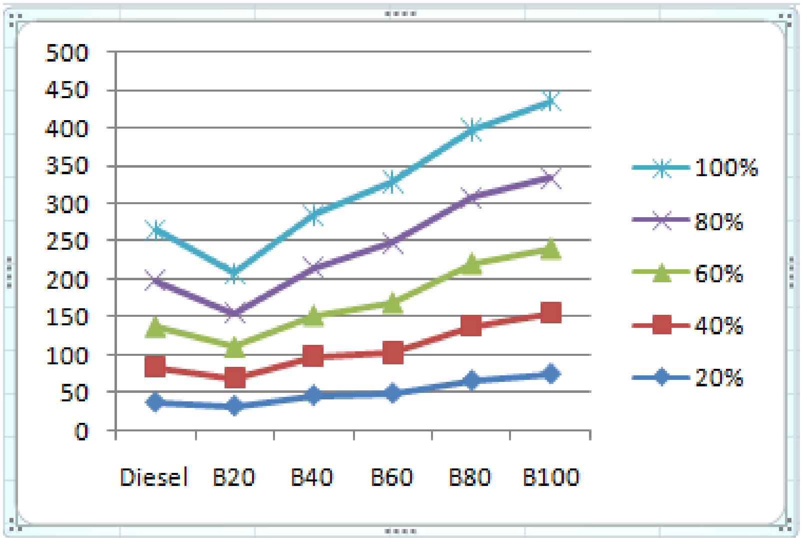


Figure 14 Load vs HC Emission

The overall performance of the jojoba seed bio-oil blended with diesel in CI engine reduces the percentage of emitted pollutants, hence with increasing quantity of biodiesel emission of HC and CO decreases. In this experiment JOJOBA (Simmondsia chinensis) oil is taken as non-edible oil and mixed with methanol makes biodiesel and this biodiesel used in diesel engine instead of diesel to get result about performance and emission of HC (hydrocarbon) and CO (carbon monoxide) so we find quantity of HC and CO reduced with increasing quantity of biodiesel. The graphical plots reveal the results of the bio-oil and predict the optimized bio-oil blend was determined.

5. Conclusions

The performance characteristics, brake thermal efficiency, brake specific fuel consumption, and emission characteristics, carbon monoxide, carbon-dioxide, oxides of nitrogen (NO), HC of a single cylinder vertical direct C.I engine using pumpkin seed bio-oil with its blends and jojoba seed bio-oil with the various blends as fuels were experimentally investigated. The following conclusions are made based on the experimental results.

Pumpkinseed Bio-oil

1. From this experiment, in SFC on increasing loads and by reduction in heat loss and better combustion at higher loads.
2. Brake Specific Fuel Consumption increases with increasing concentration of diethyl ether which slightly reduces with increasing concentration of diethyl ether.
3. Brake thermal efficiency decreases with increasing ratio of pumpkin seeds oil and additive diethyl ether in the diesel blend but 20% 40% of pumpkin seeds oil.

Jojoba seed Bio-oil

1. From the obtained biodiesel samples B20, B40, B60, B80, B100 the sample B20 produce less pollutant like CO and HC and performs greater than other blend samples.
2. In combination of both load and blend sample ratio B20 performs well in engine performance and lower emission for jojoba seed bio-oil and its blends.
3. The concentration of 1-pentanol which slightly reduces with increasing engine load.

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